



## Original Article

# Nationwide trends and in-hospital complications of trachelectomy for surgically resectable cervical cancer in Taiwanese women: A population-based study, 1998–2013



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## ABSTRACT

**Objective:** To describe the nationwide trends in the utilization of trachelectomy among Taiwanese women with surgically resectable cervical cancer over the past decade, and to compare associated demographic characteristics, in-hospital complications and related outcomes using a population-based dataset from 1998 to 2013.

**Materials and methods:** We conducted a population-based, cohort study using inpatient admission claims data of Taiwan's National Health Insurance program. Women who underwent trachelectomy for cervical cancers were compared by age at surgery (younger than 40 years, 40–59 years, and 60 years or older).

**Results:** Our study cohort consisted of 156 women. The overall utilization increased considerably during the study period, particularly in younger women aged 30–39 years. Compared with older women who had trachelectomy, women younger than 40 years were diagnosed more frequently in the later years of study (2007–2013, 69.9% vs 37.3%), were treated more frequently at medical centers (89.0% vs 60.2%) by physicians aged 55 years or older (50.7% vs 22.9%) with high case volume (50.7% vs 26.5%), were less likely to undergo concomitant surgeries for bilateral oophorectomy (1.4% vs 21.7%) and lysis of peritoneal adhesion (2.7% vs 24.1%), and were more likely to undergo lymph node excision (74.0% vs 47.0%) ( $P < 0.05$  for all). During a median of follow-up of 5.4 (2.4–9.5) years, 5.1% received future hysterectomy after trachelectomy ( $n = 8$ ) with a median time-to-future hysterectomy of 0.6 (0.2–5.0) years. The estimated risks of disease recurrence for cervical cancer and readmission within 30-days ( $n = 35$ ) were 3.8% and 22.4%, respectively. Women's age at trachelectomy had no apparent association with the length of hospital stay ( $P = 0.11$ ), in-hospital mortality, readmission within 30-days ( $P = 0.33$ ), future hysterectomy ( $P = 0.14$ ), and in-hospital complications ( $P = 0.47$ ).

**Conclusion:** Substantial increase in the trend of delayed childbearing may have influenced the decision-making of Taiwanese women with cervical cancer in favor of trachelectomy over hysterectomy over the past 16-years from 1998 to 2013. When considering the uterine preservation for future fertility, women should be counseled about the risk of disease recurrence for cervical cancer before making surgical decision for trachelectomy over hysterectomy.

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## Introduction

Cervical cancer remains an important female genital tract malignancy in women globally. In Taiwan, cervical cancer ranked as the seventh most common cancer in female in 2013 with an age-standardized incidence rate of 9.5 per 100,000 women [1]. Since many women have been delaying childbearing until their late thirties and early forties over the past decade [2], there has been a growing interest in performing trachelectomy for young women with surgically resectable cervical cancer to preserve uterus for child-bearing capacity [3–5]. In fact, nearly one-quarter (24.8%) of all incident cases of cervical cancer were diagnosed in Taiwanese women aged 30–39 [1]. However, most published studies were case reports and various small retrospective case series for benign indications such as prolapse, pelvic mass, and abnormal cervical cytology [6–9]. Other studies placed emphasis on the neonatal outcome of young women with cervical cancer [10–15]. Although the study by Hilger et al. [9] indicates a decreasing trend in the utilization of trachelectomy for benign indications based on a large single-institution case series of 310 women, no existing studies have examined the utilization of trachelectomy for surgically resectable cervical cancer using a population-based dataset. We aimed to describe the nationwide trends in the utilization of trachelectomy among Taiwanese women with surgically resectable cervical cancer over the past decade, and to compare associated demographic characteristics, in-hospital complications and related outcomes using a population-based dataset from 1998 to 2013.

## Materials and methods

### Study design

We performed a population-based, retrospective cohort study of all women who underwent trachelectomy for cervical cancer in Taiwan. The database contained de-identified data, and was approved by the National Yang-Ming University institutional review board in Taiwan (No. YM103085E-1).

### Data source

Data on incident trachelectomy for cervical cancer were retrieved from the claims information of all beneficiaries covered under Taiwan's National Health Insurance (NHI) program available in the National Health Insurance Research (NHIRD) Database [16]. The NHI is a social insurance program for all civilian residents in Taiwan with a coverage of 99% in 2010, at which time 49.8% were female [17]. In this study, we used the 1997–2013 NHI beneficiary files, registry for contracted medical facilities, registry for catastrophic illness, and medical claims for inpatient admissions as previously described [18]. The International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) codes were available for up to 5 diagnosis and 5 procedure codes per inpatient admission.

### Study population

Women who underwent trachelectomy for cervical cancer between January 1, 1998 and December 31, 2013 were selected from the inpatient admission claims using the ICD-9-CM procedure code for trachelectomy (67.4) and diagnosis code for cervical cancer (180;  $n = 184$ ). Index admission was defined as the date of hospital admission for trachelectomy on the inpatient admission claims. The laparoscopic status was defined by the procedure code 54.21 within the same inpatient admission claims of trachelectomy. To maintain homogeneity in prognosis, we excluded all women with ICD-9-CM

procedure codes for vaginal, abdominal, radical, or subtotal abdominal hysterectomies (68.3–68.7, 68.9), prior or within the same inpatient admission claims ( $n = 28$ ). The study cohort consisted of 156 women who underwent trachelectomy for cervical cancer between 1998 and 2013.

### Covariates

Women characteristics (age, Charlson comorbidity index, laparoscopic status, concomitant procedures and index year of trachelectomy), physician characteristics (age, sex, and total trachelectomy case volume), and hospital characteristics (accreditation level and institution ownership) were defined as the values at the index year. Charlson comorbidity index was used as an assessment for comorbidity, which was based on at least one inpatient claims filed within a year to a month prior to inpatient admission for trachelectomy [19]. Women with concomitant lymph node dissection were identified using the ICD-9-CM procedure codes for regional (40.3) and radical lymph node (40.4–40.5) dissections within the same inpatient admission claims of trachelectomy, whereas women with concomitant surgical lysis of peritoneal adhesion were identified using the ICD-9-CM procedure code (54.5). Women with concomitant oophorectomy were classified according to the ICD-9-CM procedure codes into partial oophorectomy (65.2), unilateral oophorectomy (also included unilateral salpingo-oophorectomy) (65.3, 65.4), and bilateral oophorectomy (also included bilateral salpingo-oophorectomy and second unilateral salpingo-oophorectomy) (65.5, 65.6). According to the definition by Huang et al. [20], physician's age was classified into one of four age categories: less than 35, 35–44, 45–54, 55 years or more. Total trachelectomy case volume was defined as the total number of trachelectomy performed by a physician between January 1, 1998 and December 31, 2013. Low-volume physicians were defined as those performed one or two trachelectomies during the study period of 16 years, middle-volume physicians performed between three and five trachelectomies, and high-volume physicians as those performing six or more trachelectomies. Medical institutions were classified as medical center, regional hospital, or district hospital [21], and as private or public ownership.

### Outcomes

The primary outcomes of the study included length of hospital stay, in-hospital mortality, inpatient readmission within 30-days, future hysterectomy, and in-hospital complications. Length of hospital stay was defined as the index admission to hospital discharge, whereas in-hospital mortality was defined by the patient discharge status code. Inpatient readmission within 30-days was based on at least one inpatient admission claims within 30 days after inpatient discharge for any cause, or administratively censored at the end of the study follow-up on December 31, 2013. Time-to-events (to future hysterectomy) was defined as the index admission to the inpatient admission date of hysterectomy (ICD-9-CM procedure codes 68.3–68.7, 68.9), death, or administratively censored at the end of follow-up on December 31, 2013. The date of death was based on the death date in the registry of catastrophic illness or ending date of coverage for all women without any inpatient claims after ending date of coverage to December 31, 2013. The following algorithm was employed to confirm the surgical indication associated with future hysterectomy (procedure codes 68.3–68.7, 68.9) rather than for another indication: (1) gynecologic cancer (diagnosis codes 179–184) took precedence over all other codes and cervical cancer was assigned the leading diagnosis whenever it was listed; (2) precancerous cervical lesion (233.1, 233.2, 622.1), genital prolapse (618), endometriosis (617),

abnormal bleeding (626), chronic pelvic pain (625), uterine leiomyoma (218) (from highest to lowest priority) was assigned the leading diagnosis if gynecologic cancer was not listed as a diagnosis; (3) the remaining leading diagnoses were assigned using the primary diagnosis codes listed within the same inpatient admission claims of future hysterectomy.

#### In-hospital complications

Potential in-hospital surgical and medical complications associated with trachelectomy were grouped into eleven categories based on multiple ICD-9-CM diagnosis or procedure codes listed within the same inpatient admission claims of trachelectomy (according to Taub et al. [22], Shah et al. [23], and Heisler et al. [24]). Surgical complications included 1) bleeding complications included post-procedure hemorrhage (diagnosis codes 998.1 excluding 998.13), acute post-hemorrhagic anemia (diagnosis code 285.1), and blood transfusion (diagnosis code V582 and procedure codes 99.0 excluding 99.08, 99.09); 2) surgical injury

(intraoperative) complications included injury to pelvic/genitourinary organs (diagnosis codes 867.0–867.9), accidental puncture or laceration during surgery (diagnosis code 998.2), and surgical repairs of laceration to urinary tract (procedure codes 56.82, 57.81, 58.41); and 3) wound complications included seroma (diagnosis code 998.13), dehiscence (diagnosis code 998.3), post-operative wound infection (diagnosis code 998.51), and non-healing surgical wound (diagnosis code 998.83). Medical complications included 1) cerebrovascular complications included central nervous system complication and iatrogenic cerebrovascular infarction or hemorrhage (diagnosis code 997.0), cerebral artery occlusion (diagnosis code 434.9), transient cerebral ischemia (diagnosis codes 435.8, 435.9), and other generalized ischemic cerebrovascular disease (diagnosis code 437.1); 2) infectious complications included sepsis (diagnosis code 038), urinary tract infection (diagnosis codes 595.9, 597.80–597.89, 599.0, 996.64), postoperative infection not otherwise specified (diagnosis codes 998.5 excluding 998.51), genital cellulites (diagnosis codes 616.1, 616.10), *Clostridium difficile* colitis (diagnosis code 008.45), pyelonephritis (diagnosis codes 590.1,

**Table 1**

Baseline women, physician and hospital characteristics of trachelectomy for cervical cancer in Taiwanese women, 1998–2013 (N = 156).

Independent variables	All (n = 156; 100%)	Younger than 40 y (n = 73; 46.8%)	40–59 y (n = 36; 23.1%)	60 y or older (n = 47; 30.1%)	P
<b>Women characteristics</b>					
Mean age (SD), y	47.3 (16.7)	32.2 (4.3)	49.5 (6.3)	69.1 (5.2)	<0.001
Charlson comorbidity index $\geq 1$ , n (%)	13 (8.3)	3 (4.1)	4 (11.1)	6 (12.8)	0.19
Laparoscopic approach, n (%)	16 (10.3)	11 (15.1)	2 (5.6)	3 (6.4)	0.18
<b>Oophorectomy, n (%)</b>					
None	123 (78.8)	69 (94.5)	20 (55.6)	34 (72.3)	<0.001
Partial	4 (2.6)	3 (4.1)	0	1 (2.1)	
Unilateral	10 (6.4)	0	3 (8.3)	7 (14.9)	
Bilateral	19 (12.2)	1 (1.4)	13 (36.1)	5 (10.6)	
Lymph node excision, n (%)	93 (59.6)	54 (74.0)	21 (58.3)	18 (38.3)	<0.001
Lysis of peritoneal adhesions, n (%)	22 (14.1)	2 (2.7)	10 (27.8)	10 (21.3)	<0.001
<b>Physician characteristics</b>					
Mean age (SD), y	50.3 (8.0)	52.7 (7.4)	48.6 (8.3)	47.9 (7.8)	<0.01
<b>Age group, n (%)</b>					
<35 y	2 (1.3)	0	2 (5.6)	0	<0.01
35–44 y	38 (24.4)	12 (16.4)	9 (25.0)	17 (36.2)	
45–54 y	60 (38.5)	24 (32.9)	16 (44.4)	20 (42.6)	
$\geq 55$ y	56 (35.9)	37 (50.7)	9 (25.0)	10 (21.3)	
Sex, n (%) (Male)	138 (88.5)	66 (90.4)	31 (86.1)	41 (87.2)	0.76
<b>Total trachelectomy case volume, n (%)</b>					
Low (1–2 procedures)	71 (45.5)	23 (31.5)	17 (47.2)	31 (66.0)	<0.01
Middle (3–5 procedures)	26 (16.7)	13 (17.8)	5 (13.9)	8 (17.0)	
High ( $\geq 6$ procedures)	59 (37.8)	37 (50.7)	14 (38.9)	8 (17.0)	
<b>Hospital characteristics</b>					
<b>Accreditation level, n (%)</b>					
District hospital	3 (1.9)	1 (1.4)	1 (2.8)	1 (2.1)	<0.001
Regional hospital	38 (24.4)	7 (9.6)	10 (27.8)	21 (44.7)	
Medical Center	115 (73.7)	65 (89.0)	25 (69.4)	25 (53.2)	
Institution ownership, n (%) (Private)	104 (66.7)	51 (69.9)	24 (66.7)	29 (61.7)	0.65
<b>Index year of trachelectomy, n (%)</b>					
1998	6 (3.8)	0	4 (11.1)	2 (4.3)	<0.001
1999	6 (3.8)	3 (4.1)	2 (5.6)	1 (2.1)	
2000	6 (3.8)	2 (2.7)	2 (5.6)	2 (4.3)	
2001	4 (2.6)	0	4 (11.1)	0	
2002	10 (6.4)	5 (6.8)	4 (11.1)	1 (2.1)	
2003	7 (4.5)	2 (2.7)	1 (2.8)	4 (8.5)	
2004	13 (8.3)	4 (5.5)	4 (11.1)	5 (10.6)	
2005	10 (6.4)	3 (4.1)	3 (8.3)	4 (8.5)	
2006	12 (7.7)	3 (4.1)	7 (19.4)	2 (4.3)	
2007	9 (5.8)	5 (6.8)	1 (2.8)	3 (6.4)	
2008	12 (7.7)	6 (8.2)	0	6 (12.8)	
2009	8 (5.1)	3 (4.1)	2 (5.6)	3 (6.4)	
2010	17 (10.9)	11 (15.1)	0	6 (12.8)	
2011	12 (7.7)	7 (9.6)	2 (5.6)	3 (6.4)	
2012	14 (9.0)	12 (16.4)	0	2 (4.3)	
2013	10 (6.4)	7 (9.6)	0	3 (6.4)	

Abbreviation: SD, standard deviation.

P (P-value,  $\chi^2$  test or one-way analysis of variance test).

590.2, 590.80, 590.9), and pneumonia (diagnosis codes 481–486, 507); 3) pulmonary insufficiency complications included post-operative pulmonary edema/insufficiency (diagnosis codes 514, 518.4) and acute respiratory failure/arrest complications (diagnosis codes 518.5, 518.81, 518.82, 799.1, 997.3); 4) thromboembolic complications included thrombosis of deep lower extremity veins and thrombophlebitis (diagnosis code 451), venous system thrombosis and embolism (diagnosis codes 453.8, 453.9), and pulmonary embolism (diagnosis code 415.1); 5) urethral obstruction (diagnosis code 593.3); 6) urinary and renal complications included urinary obstruction (diagnosis code 599.6) and retention (diagnosis code 788.2), acute renal failure (diagnosis code 584), and other unspecified urinary complications of surgical/medical care (diagnosis code 997.5); 7) post-operative myocardial infarction included acute myocardial infarction (diagnosis code 410) and cardiac complications (diagnosis code 997.1); and 8) other complications included drug and anesthetic complications (diagnosis code 995.20), postoperative shock (diagnosis code 998.0), post-operative and other complications not otherwise specified (diagnosis codes 998.8, 998.81, 998.89, 998.9), and foreign body left in after procedure (diagnosis codes 998.4, 998.7).

#### Statistical analysis

The mean (standard deviations), median (IQR, interquartile range), and frequency (%) were presented with continuous, time-to-event outcomes (survival analysis), and categorical variable, respectively. The dissimilarities in baseline characteristics, in-hospital complications and related outcomes based on women's age at trachelectomy were compared using one-way analysis of variance for continuous variables and Pearson's chi-squared for categorical variables. According to Benard et al. [25], we defined the age cut point for young women at 40 years. Women's age at trachelectomy was classified into one of three age categories: younger than 40, 40–59, 60 years or older. The national trends in the

utilization of trachelectomy for cervical cancer were illustrated descriptively, and also compared between three calendar periods (1998–2002, 2003–2007, and 2008–2013). All data transformations and statistical analyses were performed with the software package SAS for Windows® (release 9.4; SAS Institute Inc., Cary, NC). Statistical significance was defined as  $P < 0.05$  based on two-tailed tests.

## Results

### Baseline characteristics

A total of 156 women underwent trachelectomy for cervical cancer in Taiwan between 1998 and 2013. Table 1 compares women, physician and hospital characteristics of trachelectomy by age at surgery (younger than 40 years, 40–59 years, and 60 years or older). Overall, most trachelectomies were performed for younger women aged less than 40 years (46.8%) than older women (23.1% of women aged 40–59 y and 30.1% of women aged 60 y or older). Approximately 10% of trachelectomies were performed laparoscopically. Compared with older women who had trachelectomy, women younger than 40 years were diagnosed more frequently in the later years of study (2007–2013, 69.9% vs 37.3%), were treated more frequently at medical centers (89.0% vs 60.2%) by physicians aged 55 years or older (50.7% vs 22.9%) with high case volume (50.7% vs 26.5%), were less likely to undergo concomitant surgeries for bilateral oophorectomy (1.4% vs 21.7%) and lysis of peritoneal adhesion (2.7% vs 24.1%), and were more likely to undergo lymph node excision (74.0% vs 47.0%) ( $P < 0.05$  for all).

### Trend analysis

The utilization of trachelectomy for cervical cancer remained relatively stable between 1998 and 2001 (4–6 cases per year), and increased by 1.83-fold from 4 cases in 2001 to 17 cases in 2010, followed by a drop to 10 cases in 2013 (Fig. 1). The overall utilization

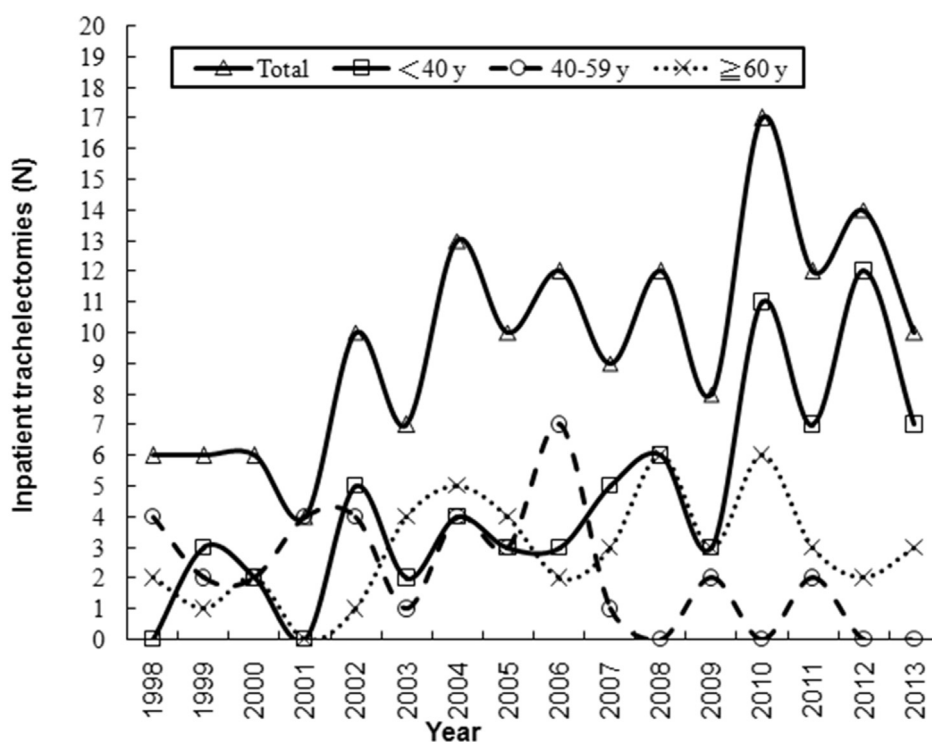


Fig. 1. Nationwide utilization trend of trachelectomy for cervical cancer by age group and year, 1998–2013 (N = 156).

rate increased in women younger than 40 years over the study period, particularly in women aged 30–39 years (data not shown). Fig. 2 compares the nationwide utilization trend of trachelectomy between the periods 1998–2002, 2003–2007, and 2008–2013 by age at surgery. The utilization increased at women younger than 40 years and those 60 years or older for all periods. However, women aged 40–59 years decreased its utilization after year 2008.

#### In-hospital complications and related outcomes

Table 2 compares the unadjusted in-hospital complications and related outcomes for cervical cancer by age at surgery during a median (IQR) follow-up time of 5.4 (2.4–9.5) years. Women's age at trachelectomy had no apparent association with the length of hospital stay ( $P = 0.11$ ), in-hospital mortality, readmission within 30-days ( $P = 0.33$ ), future hysterectomy ( $P = 0.14$ ), and in-hospital complications ( $P = 0.47$ ). Approximately 5% of women had future

hysterectomy ( $n = 8$ ) with a median time-to-future hysterectomy of 0.6 (0.2–5.0) years. The estimated risks of disease recurrence for cervical cancer ( $n = 6$ ) and readmission within 30-days ( $n = 35$ ) were 3.8% and 22.4%, respectively. Most trachelectomies had no in-hospital complications (83.3%). The most common were bleeding, infectious, surgical injury (intraoperative), and urinary and renal complications at 5.8%, 5.1%, 2.6% and 2.6%, respectively. The assessment of the risk of wound, cerebrovascular, pulmonary insufficiency, thromboembolic, urethral obstruction, postoperative myocardial infarction, and other complications after trachelectomy was not possible due to limited or no outcome events.

#### Discussion

We found an overall increase in the utilization of trachelectomy for women with surgically resectable cervical cancer over the past 16-years from 1998 to 2013 among Taiwanese women. Compared

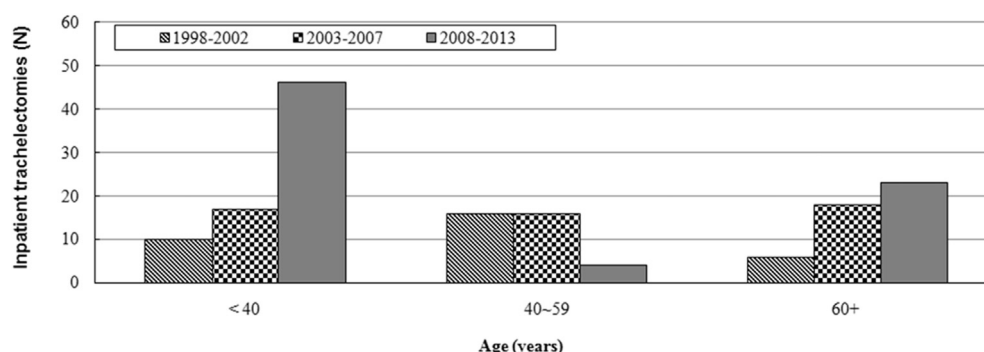


Fig. 2. Nationwide utilization trend of trachelectomy for cervical cancer by age group and periods 1998–2002, 2003–2007, and 2008–2013 ( $N = 156$ ).

Table 2

Unadjusted in-hospital complications and related outcomes associated with trachelectomy for cervical cancer in Taiwanese women, stratified by age (1998–2013,  $N = 156$ ).

Independent variables	All ( $n = 156$ ; 100%)	Younger than 40 y ( $n = 73$ ; 46.8%)	40–59 y ( $n = 36$ ; 23.1%)	60 y or older ( $n = 47$ ; 30.1%)	<i>P</i>
Length of hospital stay, mean (SD), d	12.3 (10.1)	11.8 (8.3)	15.3 (13.0)	10.8 (9.9)	0.11
In-hospital mortality, $n$ (%)	0	0	0	0	
Inpatient readmission within 30-days, $n$ (%) <sup>a</sup>	35 (22.4)	19 (26.0)	9 (25.0)	7 (14.9)	0.33
<b>Future hysterectomy, <math>n</math> (%)<sup>b</sup></b>					
Median time-to-event (IQR), y	0.6 (0.2–5.0)	2.2 (0.3–6.7)	0.2 (0.1–0.3)	0	
Indications:	8 (5.1)	6 (8.2)	2 (5.6)	0	0.14
Cervical cancer	6 (3.8)	4 (5.5)	2 (5.6)	0	
Ovarian cancer	1 (0.6)	1 (1.4)	0	0	
Uterine leiomyoma	1 (0.6)	1 (1.4)	0	0	
Surgical or medical complication, $n$ (%) <sup>c</sup>	26 (16.7)	12 (16.4)	4 (11.1)	10 (21.3)	0.47
More than one complications, $n$ (%)	2 (1.3)	1 (1.4)	1 (2.8)	0	0.53
<b>Surgical Complications</b>					
Any complication	13 (8.3)	8 (11.0)	1 (2.8)	4 (8.5)	0.35
Bleeding	9 (5.8)	5 (6.8)	1 (2.8)	3 (6.4)	0.68
Surgical injury (intraoperative)	4 (2.6)	3 (4.1)	0	1 (2.1)	0.43
Wound	0	0	0	0	
<b>Medical Complications</b>					
Any complication	13 (8.3)	4 (5.5)	3 (8.3)	6 (12.8)	0.37
Cerebrovascular	0	0	0	0	
Infectious	8 (5.1)	1 (1.4)	2 (5.6)	5 (10.6)	0.08
Pulm. insufficiency	0	0	0	0	
Thromboembolic	2 (1.3)	0	1 (2.8)	1 (2.1)	0.40
Urethral obstruction	1 (0.6)	1 (1.4)	0	0	
Urinary and renal	4 (2.6)	3 (4.1)	1 (2.8)	0	0.38
Myo infarction	0	0	0	0	
Other complication	0	0	0	0	

Abbreviations: IQR, interquartile range; Myo infarction, myocardial infarction; Pulm insufficiency, pulmonary insufficiency; SD, standard deviation.

*P* (*P*-value,  $\chi^2$  test or one-way analysis of variance test).

<sup>a</sup> One women was discharged after December 1, 2013, and had less than 30 days of follow-up for the assessment of inpatient readmission.

<sup>b</sup> The median (IQR) follow-up time of all patients was 5.4 (2.4–9.5) years.

<sup>c</sup> A women may have more than one complications.



with older women, women younger than 40 years (particularly in younger women aged 30–39 years) were diagnosed more frequently in the later years of study, were treated more frequently at medical centers by physicians aged 55 years or older with high case volume, were less likely to undergo concomitant surgeries for bilateral oophorectomy and lysis of peritoneal adhesion, and were more likely to undergo lymph node excision. Women's age at trachelectomy had no apparent association with the length of hospital stay, in-hospital mortality, readmission within 30-days, future hysterectomy, and in-hospital complications.

Our findings suggest that the overall utilization rate of trachelectomy has increased over the study period in women with surgically resectable cervical cancer. A possible explanation for the increasing trend could be attributed to the substantial increase in the trend of delayed childbearing in younger women. Delayed childbearing is a recent global phenomenon that has increased among young women aged 30 or more ever since 1990 in the United States [2] and Taiwan [26]. The vast majority of cervical cancer were diagnosed in women aged 30–39 years in both the United States (78%; years 1999–2008) [25] and Taiwan (83.6%; year 2013) [1]. When young women are diagnosed with surgically resectable cervical cancer, trachelectomy has becoming a popular alternative over hysterectomy for the preservation of future fertility [3–5]. Only 13.3% of Taiwanese women younger than 40 years underwent radical hysterectomy for gynecologic cancer (mostly cervical cancer) [27], whereas, in this study, 46.8% of trachelectomy was performed in these women. Given that only 1.4% of these women had bilateral oophorectomy, we speculated that these young women who chose fertility-preserving trachelectomy over conventional hysterectomy were expected to preserve the uterus for future pregnancy [4]. Due to limited numbers of young women with trachelectomy for cervical cancer, further studies are needed to refine and test this causal inference in Taiwanese women. We are unable to compare our findings with other published study because, to my best knowledge, there is currently no published trend study on trachelectomy for cervical cancer.

Recurrent disease in the corpus uteri is a major concern for gynecologists when trachelectomy is used in place of hysterectomy. In our study, the estimated risk of disease recurrence for cervical cancer was 3.8%. Similar to our findings, several studies also showed recurrence rates of less than 4% for cervical cancer after trachelectomy, including Shepherd and Milliken [10] (2.5%), Beiner and Covens [28] (2.8%), Diaz et al. [15] (2.5%), and Bernardini et al. [14] (3.6%). Other studies showed a slightly higher recurrence rates of 4–6%, including Plante et al. [29] (4.2%), Hertel et al. [30] (4.0%), Marchiole et al. [31] (5.9%), and Dargent et al. [32] (4.3%). Although limited recurrent events are observed, women who consider trachelectomy over hysterectomy for cervical cancer should carefully weigh not only the fertility-preserving option of the procedure, but should also evaluate the potential risk of disease recurrence in the future.

The current study has several strengths. First, to our knowledge, we present the first population-based trend study on trachelectomy for cervical cancer. Second, we are also the second study to analysis in-hospital complications on trachelectomy for cervical cancer in a large sample of Chinese women with more than 100 cases after Cao et al. [33]. Third, since all women have similar access to the universal, single-payer NHI health care system in Taiwan, the selection bias associated with the observed national trends is deemed minimal. Fourth, the nationally uniform criteria used in the inpatient admission claims have minimized ascertainment biases of the in-hospital surgical and medical complications, readmission, and subsequent hysterectomy associated with trachelectomy. In addition, the Bureau of NHI randomly sampled medical claim data and patient charts from every hospital annually to improve the

accuracy of the NHIRD database [34–38]. As a reliable data source, the NHIRD has been used in various clinical research fields [18,39–42]. On the other hand, the current study has several inherent limitations of an administrative claim database. First, it lacks clinical variables such as disease severity, pathologic reports, or cancer staging information, which may confound our results. We have used Charlson comorbidity index as a proxy measure for disease severity, and assumed all surgically resectable cervical cancer as early stage diseases. Second, the ICD-9-CM coding system employed in the NHIRD database used herein does not distinguish between different routes of trachelectomy, and prevents us from investigating approach-related morbidities for trachelectomy. Third, our analyses for in-hospital complications and related outcomes stratified by age are unadjusted results due to limited outcome events of readmission, future hysterectomy and in-hospital complications.

## Conclusions

Our study describes the apparent increasing utilization of trachelectomy for cervical cancer among Taiwanese women over the past 16-years from 1998 to 2013. Substantial increase in the trend of delayed childbearing may have influenced the decision-making of these women in favor of trachelectomy over hysterectomy during the study period. When considering the uterine preservation for future fertility, women should be counseled about the risk of disease recurrence for cervical cancer before making surgical decision for trachelectomy over hysterectomy.

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## Conflict of interest

The authors declare no conflicts of interest.

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